REMARKS

By the present amendment claims 1 to 3 and 5 are under consideration in the application. Claim 6 has been withdrawn due to the restriction requirement.

Restriction Requirement

Applicants hereby affirm the election of the claims of Group I, i.e., claims 1 to 5, for further prosecution in this application.

The election is made without prejudice to the filing of a divisional patent application directed to the subject matter of non-elected claim 6.

Non-elected claim 6 is dependent on independent claim 1 and incorporates by reference all the limitation of independent claim 1. If independent claim 1 is found allowable, it is respectfully requested that withdrawn, non-elected dependent claim 6 be rejoined to the application.

Amendments To The Specification

The specification has been amended to correct minor typographical type errors. The amendment of equation <2>' at page 9, lines 17-18 may be found in the specification, e.g., at page 3, lines 13-14.

Amendments To The Claims

Support for the amendment to claims 1 and 2 setting the lower limit of Si as --1.0%-- may be found in Table 1 of the specification at page 13 where the lowest amount of Si for Steels A to D and F to Z is 1.0% Si. Note that 0.4% Si of Steel E is a non-preferred amount of the preferred range of Si being 0.9 to 1.3% as disclosed in the specification at page 5, lines 14-16.

Support for amending claims 1 and 2 to recite --wherein the steel of said steel sheet contains substantially no Mg-- may be found in the specification as follows. The specification at page 7, lines 20 to 21 clearly discloses that Mg is an optional chemical

component. Table 1 at page 13 of the specification disclose steels A to S which contain no Mg. Insubstantial amounts of Mg would be provided for by the "unavoidable impurities" of claims 1 and 2.

Claim Objections

Claim 3 (should be Claim 2) was objected to because equation "<3>" should read --<3>'--.

In response to this objection, claim 2 has been amended by the present amendment.

In view of the present amendment, it is respectfully requested that the claim objection be withdrawn.

§103

Claims 1 to 5 were rejected under 35 U.S.C. §103(a) as being unpatentable over Japan No. 2001-342543 or U.S. Patent No. 6,364,968 to Yasuhara et al. alone or in view of U.S. Patent No. 5,470,529 to Nomura et al.

These rejections, as applied to the amended claims, are respectfully traversed.

The Present Invention

The present invention provides as claimed in the amended claim 1, a high-strength hot-rolled steel sheet excellent in hole expandability, and ductility, consisting essentially of, in terms of mass %.

C: 0.01 to 0.09%, Si: 1.0 to 1.5%, Mn: 0.5 to 3.2%, Al: 0.003 to 1.5% P: 0.03% or below, S: 0.005% or below, Ti: 0.10 to 0.25%, Nb: 0.01 to 0.05%, and the balance being iron and unavoidable impurities, wherein the steel of said steel sheet contains substantially no Mg and satisfying all of the following formulas <1> to <3>:

$0.9 \leq 48/12 \times C/Ti < 1.7$ . . . <1>

$50,227 \times C - 4479 \times Mn > -9860$ . . . <2>

$811 \times C + 135 \times Mn + 602 \times Ti + 794 \times Nb > 465$ . . . <3>, and

having strength of at least 980 N/mm^2, and as claimed in the amended claim 2, a high-strength hot-rolled steel sheet excellent in hole expandability, and ductility, consisting essentially of, in terms of mass %:

C: 0.01 to 0.09%, Si: 1.0 to 1.5%, Mn: 0.5 to 3.2%, Al: 0.003 to 1.5%, P: 0.03% or below, S: 0.005% or below, Ti: 0.10 to 0.25%, Nb: 0.01 to 0.05%, and at least one of Mo: 0.05 to 0.40% and V: 0.001 to 0.10%, and the balance being iron and unavoidable impurities, wherein the steel of said steel sheet contains substantially no Mg and satisfying all of the following formulas <1>' to <3>':

$0.9 \leq 48/12 \times C/Ti < 1.7$ . . . <1>'

$50,227 \times C - 4479 \times Mn > -9860$ . . . <2>'

$811 \times C + 135 \times (Mn + 0.57 \times Mo + 1.08 \times V) + 602 \times Ti + 794 \times Nb > 465$

. . . <3>',

and having strength of at least 980 N/mm^2.

In order to obtain an high-strength hot-rolled steel sheet having strength of at least 980 N/mm^2, one rank higher than that of the steel sheet disclosed in the cited references (discussed later), and also having excellent hole expandability and ductility, the present invention utilizes strengthening due to TiC precipitation and the influence of structure strengthening due to C and Mn on the properties of steel material, and defines the range of the components C, Mn, and Ti by formulas <1> (<1>') and <2> (<2>'), and further defines the range of components Mn, Ti, Nb and/or Mo and V by the formula <3> (<3>').

As described in the specification, e.g., at page 9, lines 19 to 31, although in the steel sheet having a strength level of 780N/mm^2, it is sufficient and easy to satisfy formulas <1> and <2> to obtain formability while securing the strength, it is essential that the components further satisfy formula <3> to, in accordance with the present invention, obtain the strength of at least 980 N/mm^2 of the present invention.

That is, according to the present invention, the high-strength hot-rolled steel sheet excellent in hole expandability and ductility and having strength of at least 980 N/mm^2 can be obtained by defining the composition and controlling the content of components so as to satisfy the three formulas of <1> to <3> (<1>' to <3>').

Patentability

Japan No. 2001-342543 ("JP '543")

JP '543 relates to a high-strength hot-rolled steel sheet having hole expandability and ductility and discloses a hot-rolled steel sheet comprising: by weight %, C: 0.01% - 0.20%, Si: 0.3% - 1.5%,, Mn: 0.5 - 2.5%, P: 0.10% or below, S: 0.009% or below, N: 0.010% or below, Mg: 0.0005% - 0.01%, Al: 0.002% - 0.07%, one or more of Ti: 0.003% - 0.25% and Nb: 0.003% - 0.04%, and the balance iron with inevitable impurities, and containing MgO or complex oxides which are composed MgO and one or more of Al_2O_3, SiO_2, MnO and Ti_2O_3 with the range of particle diameter of 0.005 - 5.0 μm, in 10 x 10^3 to 1.0 x 10^7 pieces per 1 mm^2, and the steel structure being mainly a ferrite structure and the residue being a bainite structure. (See English Abstract of JP '543).

The steel sheet disclosed in JP '543 secures a strength of the 590 to 780 N/mm^2 class, hole expandability and ductility (See Problem To Be Solved in Abstract of JP '543) by essentially adding Mg to the steel and finely dispersing a specified number of pieces of MgO or composite oxides composed of MgO and one or more of Al_2O_3, SiO_2, MnO and Ti_2O_3.

On the other hand, as explained above, in the steel sheet of the present invention, it is essential to satisfy the formula <1> to <3> (<1>' to <3>') in order to secure a strength of at least 980 N/mm^2, hole expandability and ductility without the steel substantially containing Mg.

Although high strength may be obtained without satisfying formula <3>, if the formula <3> is not satisfied, the hole expandability is deteriorated as shown in the Example steels V1 and V2 in the Table at page 11 of JP '543.

The Example steels V1 and V2 in this Table of JP '543 satisfy the formulas <1> and <2>, however the value of the formula <3> is 464.75 and does not satisfy formula <3> which requires the value to be more than 465.

This claim limitation that the value of the formula <3> has to be more than 465 is essential for the preset invention.

In addition this steel of JP '543 contains Mg and therefore the composition of JP '543 is different from the present invention.

JP '543 does not disclose or suggest the present invention.

Further, although Example steel sheets V1 and V2 of JP '543 have a high strength of 1043 N/mm^2 and 1038 N/mm^2 respectively, the hole expandability is 55% and 65% respectively, despite containing Mg effective for improving hole expandability. That is, the hole expandability of these Example V1 and V2 steel sheets of JP '543 is almost the same level as Example steel sheets A and B (50% to 70%) of the present invention having almost the same strength level and containing no Mg. See Tables 1 and 3 of the specification of the present application.

The steel sheet of the present invention has an excellent ductility and hole expandability with high strength, without substantially containing Mg.

As examples of steel containing little Mg, Comparative Examples A4 to A6 having little or no Mg content are shown in JP '543. See Tables at pages 8 and 9 of JP 543.

Although the hole expandability of these Comparative Examples A4 to A6 is good, 70 to 75%, the strength is low, 694 - 695N/mm^2.

To the contrary, although the steel sheet of the present invention contains substantially no Mg, the steel sheet of the present invention secures an excellent hole expandability of 48 to 73% having a high strength of at least 980N/mm^2 by satisfying the formulas <1> to <3> (<1>' to <3>').

As explained above, it is essential for the steel sheet of the present invention to satisfy the formulas <1> to <3> (<1>' to <3>') to secure a high strength of at least 980N/mm^2, excellent hole expandability and ductility while containing substantially no Mg.

In other words, since the composition of the steel sheet is defined so as to satisfy these formulas, the steel sheet of the present invention can secure a high strength of at least 980N/mm^2, excellent hole expandability and ductility without substantially containing Mg.

In addition, the technology disclosed in JP '543 adds Mg and stresses control of composite oxides relating to Mg, and discloses oxides generated by added elements of Al, Ti, and Nb.

However, JP '543 does not disclose or suggest containing substantially no Mg, controlling TiC and defining the range of C, Mn, Ti, Nb, and further Mo and V by the formulas <1> to <3> (<1>' to <3>'), and thereby securing a high strength of at least 980N/mm^2, excellent hole expandability and ductility.

As explained above, the present invention enables a high strength hot-rolled steel sheet having strength of at least 980N/mm^2, excellent hole expandability and ductility without substantially containing Mg.

Therefore, independent claims 1 and 2, and all claims dependent thereon, are patentable over JP 543.

U.S. Patent No. 6,364,968 ("US '968")

US '968 relates to a high strength hot-rolled steel sheet having stretch flangeability and a method for producing the same and discloses a steel sheet having a composition containing: C: about 0.05 - 0.30 wt%, Si: about 0.03 - 1.0 wt%, Mn: about 1.5 - 3.5 wt%, P ≤ about 0.02 wt%, S ≤ about 0.005 wt%, Al ≤ about 0.150 wt%, N ≤ 0.0200 wt%, one or more of Nb: 0.003 - 0.20 wt%, Ti: about 0.005 - 0.20 wt% and the balance consisting of Fe and unavoidable impurities. The steel sheet has a microstructure having fine bainite grains with a size of about 3.0 μm or less at an area ratio of 90% or more.

The steel sheet disclosed in US '968 contains 1.0% or less of Si (about 0.03 to 1.0%), while, as amended, the steel sheet of the present invention contains 1.0 or more of Si.

US '968 Col. 6, lines 8 to 20 discloses Si is an element useful to increase tempering softening resistance when strengthening by the transformed structure is utilized.

Si is required to be added in content of not less than about 0.03 wt%. However, US '968 discloses Si exhibits an action to increase hot deformation resistance and if Si is added in excess of about 1.0 wt%, hot rolling into thin sheet becomes difficult. US '968 defines the Si content as 1.0 wt% or less.

The Examples of US '968 (Table 1) all have a Si content of less than 1.0 wt%. Comparative Example Steel No. 8 has an Si content of 0.11% but also has an Nb content of 0.25% which is far in excess of the maximum 0.05% Nb of the present invention.

US '968 clearly teaches against an Si content of 1.0 wt% or more.

On the contrary, the present invention adds 1.0% or more by mass (1.0 to 1.5%) of Si to improve elongation and obtain both strength and ductility for the steel sheet.

US '968 makes no disclosure or suggestion with respect to equations <1> to <3> (<1>' to <3>').

It is therefore submitted that independent claims 1 and 2, and all claims dependent thereon, are patentable over US '968.

U.S. Patent No. 5,470,529 ("US '529")

US '529 relates to a high tensile strength steel sheet having improved formability and discloses a steel sheet consisting essentially, in terms of weight, C: 0.10 - 0.25%, Si <2.0%, Mn: 0.5 - 2.5%, Al: 0.25 - 2.0%, wherein $1.0 \leq Si\ (\%) + Al\ (\%) \leq 2.5$, Cu: 0.1 - 2.0%, Ni: 0 - 1.10% and $Ni\ (\%) \geq Cu\ (\%) / 3$, Cr: 0 - 5.0%, Ca: 0 - 0.01%, Zr: 0 - 0.10%, REM: 0 - 0.10%, Nb; 0 - 0.10%, Ti: 0 - 0.10%, V: 0 - 0.20%, and a balance of Fe and inevitable impurities with N being limited to 0.01 or less, the steel sheet having at least 5% by volume of retained austenite and $Cu\ (\%) \geq Si\ (\%)$.

However, the steel sheets disclosed in US '529 all have low strength, 601 to 902 MPa shown in Tables 3-1, 3-2, 4-1 and 4-2, and do not satisfy the requirement of 980 N/mm^2 or higher of the present invention.

Note that although the Examples of Run No. 15, 18 and 19 in Table 6 of US '529 show a tensile strength of 1224Mpa, 986MPa and 1408MPa, respectively, and satisfy the requirement of 980 N/mm^2 or higher of the present invention, C content of the steel composition (I, L, M) of these steel sheets is 0.15, 0.27% and 0.47%, respectively, and is far outside the range of the present invention.

Further, note that although the Examples of Run No. 34, 41 and 45 in Table 7 show tensile strength of 1702Mpa, 1311 MPa and 1311 MPa, respectively and satisfy the requirement of 980 N/mm^2 or higher of the present invention, C content of the steel composition (D, I, M) of these steel sheets is 0.24%, 0.15% and 0.47%, respectively and is far outside the range of the present invention.

Likewise, note that although the Examples of Run No. 19 and 20 in Table 9 show tensile strength of 1052 Mpa and 1086 MPa, respectively, and satisfy the requirement of 980 N/mm^2 or higher of the present invention, C content of the steel composition (19, 20) of these steel sheets is 0.28% and 0.48%, respectively, and is far outside the range of the present invention.

Although C is also added to secure strength in the present invention, the range of C content is limited to 0.01 to 0.09% in order to obtain excellent hole expandability and ductility.

In the present invention, in order to secure strength of 980 N/mm^2 or higher while limiting the C range to a low content, the present invention defines the formula <3> and controls the composition so as to satisfy this formula.

It is therefore submitted that independent claims 1 and 2, and all claims dependent thereon, are patentable over JP '543 and/or US '968 in view of US '529.

CONCLUSION

It is submitted that in view of the present amendment and foregoing remarks, the application is now in condition for allowance. It is therefore respectfully requested that the application, as amended, be allowed and passed for issue.

Respectfully submitted,

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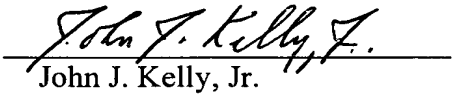
By: 
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